CHAPTER 5
CONCLUSIONS

5-1. Results

Located in appendix B are the results from the data collection effort representing the PREP database. This database contains the reliability and maintainability metrics for over 200 components that were the focus of this study.

a. The database is presented in a hierarchical structure to provide the analyst with numeric options if the exact component is not identified. As an example, the CATEGORY of Accumulator is comprised of two CLASSES (Pressurized and Unpressurized). Each of the CLASSES is comprised of individual data points. A reliability numeric is derived for each data point listed within a CLASS and displayed in columns in the database report.

b. The numeric is then rolled-up to the CLASS level to indicate a combination of information within each CLASS. Subsequently the data from the CLASS level is rolled-up into the CATEGORY level. The reliability numeric becomes more generically applied to the item as the information is rolled-up to the next higher level. Where we had various sizes as with transformer capacities, information was combined to create a general transformer number.

c. In table 5-1 are the reliability and maintainability metrics with associated formulas that were used to develop the PREP database. Acronyms and definitions of each category are provided in the glossary. These definitions are referenced in several reliability publications and the formulas can be verified in the *Reliability Toolkit: Commercial Practices Edition*, page 12, or MIL-HDBK-339, *Custom Large Scale Integrated Circuit Development & Acquisition for space Vehicles*, or in the IEEE standard definition publication.

Table 5 -1. Reliability and Maintainability Calculations

Calculated Data	Formula for Calculation
Ai, Inherent Availability	Ai = MTBF/(MTBF+MTTR)
Ao, Operational Availability	Ao = MTBM/(MTBM+MDT)
λ, Failure Rate (failures/hour(h))	λ = Tf/Tp
λ_y, Failure Rate (failures/year(y))	λ_y = Tf/(Tp / 8760)
MDT, Mean Down Time (h)	MDT = (Rdt + Rlt + Mdt) / Tde
MTBF, Mean Time Between Failures (h)	MTBF = Tp / Tf
MTBM, Mean Time Between Maintenance (h)	MTBM = Tp / Tde
MTTM, Mean Time To Maintain (h)	MTTM = Mdt / Tma
MTTR, Mean Time To Repair (h)	MTTR = Rdt / Tf
R(t), Reliability (for time interval t)	$R(t) = e^{-\lambda t}$
Hrdt/Year, Hours Downtime per Year	Hrdt/Year = (1 - Ao) × 8760

Where:

Mdt (maintenance downtime): The total downtime for preventative maintenance (including logistics delay time, which includes spare parts availability, crew availability, etc) for a given Tp. (hours).

Rdt (repair downtime): The total downtime for corrective maintenance (excluding logistics delay time) for a given Tp. (hours).

Rlt (repair logistics time): The total logistics delay time for corrective maintenance for a given Tp. (hours).

Tde (total downtime events): The total number of downtime events (including both preventative maintenance and corrective maintenance) during the Tp

Tf (total failures): The total number failures during the Tp

Tma (total maintenance actions): The total number of preventative maintenance actions which take the component down during the Tp

Tp (total period): The calendar time over which data for the item was collected (hours)

t : time interval.

d. Also you will note, in the database located in appendix B, some items have no failures during the time of the analysis. Therefore, for these items with 0 failures, reliability statistics are calculated using the Chi Squared 60% confidence interval based on time truncated data. This common approach to data with no failures associated with the data collection time frame is explained in MIL-HDBK-338B, *Electronic Reliability Design Handbook*, section 8.3.2.5.2, Confidence Limits – Exponential Distribution. These items are identified by an asterisk (*) in the database report. Any metrics for which no data were available at the time of the analysis are identified by x's.

5-2. Benefits

The information collected in this study can be useful in determining various performance capabilities along with maintenance strategies. The actual values that can be predicted for a specific system from the use of this data are not necessarily the actual results that the facility may encounter. The value of using the data is to establish a baseline for the facility to use as a comparison.

a. Upon review of this document the facility engineer should be able to make a more knowledgeable assessment of the quality and history of the data provided in appendix B of this manual. The background information and the description of the whole analysis process should provide a level of accuracy of the data. With a better understanding of the data history, the facility engineer or designer can apply the data with a more comfortable level of confidence.

b. The data and procedure can be used in different manners to aid the facility designer and facility engineer. The designer can use the data to evaluate different designs. The engineer can estimate the length of downtime by adding the failure time to the production or mission loss and can estimate the total length of time from line stop to line start as a result of failures.

c. The data will facilitate evaluations of new designs or redesigns in order to minimize the production/mission failure with estimates on money saved by avoiding downtime. With the data the engineer can estimate the downtimes associated with the systems or sub-systems and compare these results to the actual times. This could identify problem areas that may need more (or less) maintenance time and systems that may benefit from redundancy or replacement.

d. The data represented in the PREP database is the foundation for conducting many types analyses. This data is invaluable for supporting these different analyses used to measure efficiencies and deficiencies in a facility's system.